NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
June 1943 as
Memorandum Report

THE LOCUS OF POSSIBLE POSITIONS OF A HEAVY BOMBER IN SPACE AFTER A 12-SECOND TIME INTERVAL

By Charles W. Mathews and Clotaire Wood

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA

WASHINGTON

L - 206

70925711

3594257

MEMORANDUM REPORT

for the

National Defense Research Council

THE LOCUS OF POSSIBLE POSITIONS OF A HEAVY BOMBER IN SPACE AFTER A 12-SECOND TIME INTERVAL

By Charles W. Mathews and Clotaire Wood

INTRODUCTION

At the request of the National Defense Research Council, calculations have been made to determine the loci of possible positions of a heavy bomber in space following a 12-second interval. The airplane flight paths corresponding to various limiting maneuvers were calculated to determine the position of the airplane at the end of the 12-second time interval.

The calculations were made for a hypothetical airplane having characteristics similar to those of a B-24 airplane.

PROCEDURE AND ASSUMPTIONS

Flight paths were determined by step-by-step integration for various extreme maneuvers entered from level flight at an altitude of 15,000 feet. Entrance speeds of 225 miles per hour and 276 miles per hour corresponding to 60 percent and 100 percent rated power, respectively, were investigated. Except where otherwise specified, the limiting positions of the airplane were determined for two power changes that were made at the start of the maneuvers. These changes consisted of applying full throttle (109 percent rated engine power) and completely throttling the engines.

The loci of possible airplane positions were determined by calculating the airplane flight paths for the following extreme maneuvers:

1. Abrupt climbing and diving maneuvers in the vertical plane limited by maximum lift coefficient or maximum permissible normal acceleration.
2. Climbing and diving maneuvers in the vertical plane at fixed flight path angles.
3. Level turns limited by maximum lift coefficient or maximum permissible normal acceleration.
4. Level turns with recovery after various time increments.
5. Full-throttle climbing turns with a 60° angle of bank limited by maximum lift coefficient or maximum permissible normal acceleration.
6. Full-throttle diving turns with a 30° angle of bank limited by maximum permissible negative normal acceleration.
7. Diving turns consisting of straight dives for 3 seconds followed by turns with vertical bank limited by maximum permisible normal acceleration.
8. Turns with vertical bank limited by maximum lift coefficient or maximum permissible normal acceleration.

The assumed characteristics of the airplane investigated are listed below: (The wing area, engine power, gross weight, and limiting accelerations were taken from specifications of the B-24 airplane.)

1. Wing area: 1048 square feet
2. Gross weight: 50,000 pounds
3. Power: four engines, normal rating 1100 horsepower each
4. Maximum lift coefficient:

   power off 1.3

   full throttle 1.5
5. Maximum rolling velocity:

   For the maneuvers involving roll, the rates of roll were determined on the basis of a wing-tip helix angle of 0.08 radian at 225 miles per hour. For higher speeds, the rate of roll was assumed to drop off inversely with increase in speed because of increased stick forces.
6. Profile-drag coefficient: 0.0325
7. Maximum allowable normal acceleration: 3g, -1g
8. Power absorbed by each windmilling propeller:

   60 horsepower (reference 1)

   The variations of normal acceleration and rolling velocity with time used in calculating the rate of entry into the various maneuvers were

estimated from available flight test data showing response of airplanes to abrupt control manipulations.

RESULTS AND DISCUSSION

The results of the calculations are presented as plots of the flight paths and as side views and horizontal sections of the loci. Figures 1 through 5 show the results obtained for the 60-percent power entrance condition. Figures 6 through 10 show the results obtained for the 100-percent power entrance condition.

Figures 1 through 4 and 6 through 9 show plots of the calculated flight paths for all the maneuvers investigated. The points shown on these paths represent the positions of the airplane at 1-second intervals. The locus of airplane positions for any period of time less than 12 seconds can be determined by fairing the points corresponding to a given time.

Figure 5 shows the side view and horizontal sections of the calculated locus for the 60-percent entrance power condition. Figure 10 shows the side view and horizontal sections of the calculated locus for the 100-percent entrance power condition.

It may be noted that the locus of airplane positions for either the 60-percent or 100-percent power entrance condition is bounded by two curved surfaces with their concave sides facing the initial position of the airplane. The inner surface is determined by engine-throttled maneuvers and the outer surface by full-throttle maneuvers. The distance

between these two surfaces is relatively small and averages about 300 feet for the 60-percent power entrance condition and 250 feet for the 100-percent power entrance condition.

The following maximum displacements from the initial position of the airplane at the end of the 12-second interval were obtained from the two assumed entrance power conditions:

1. Maximum gain in altitude -

   60-percent power, 970 feet

   100-percent power, 1650 feet

2. Maximum loss in altitude -

   60-percent power, 2290 feet

   100-percent power, 2250 feet

3. Maximum lateral displacement -

   60-percent power, 2690 feet

   100-percent power, 2830 feet

4. Maximum displacement parallel to original line of flight -

   60-percent power, 4350 feet

   100-percent power, 5150 feet

It should be remembered that the loci calculated represent the limiting positions of the airplane that would be obtained by flying the airplane at its structural and aerodynamic limits. The extent to which the extreme

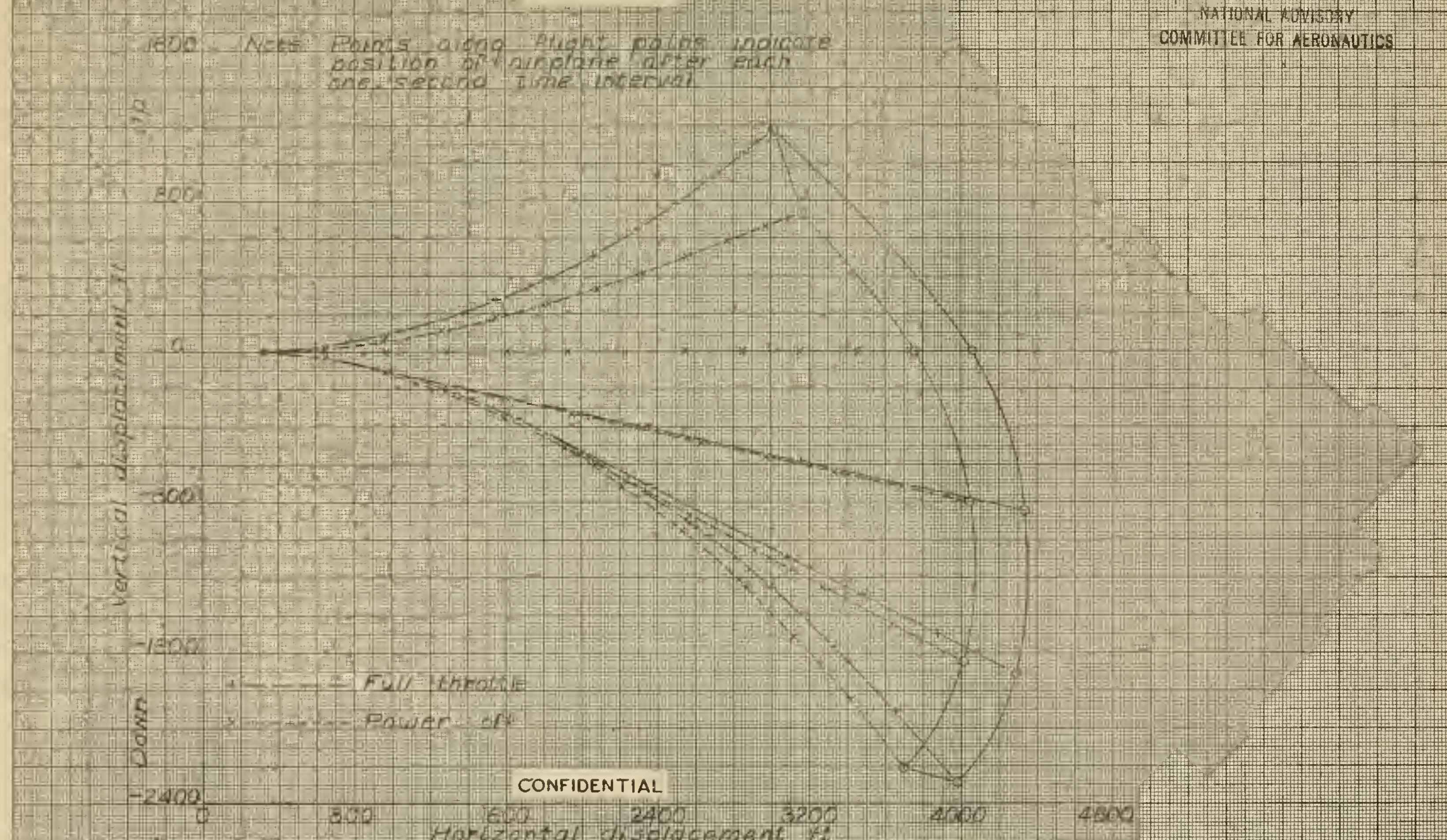
boundaries of the loci would be utilized would depend to some extent on the skill of the pilots and primarily on the incentive involved.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 8, 1943.

REFERENCE

1. Hartman, Edwin P., and Biermann, David: The Negative Thrust and Torque of Several Full-Scale Propellers and Their Application to Various Flight Problems. Rep. No. 641, NACA, 1938.

CONFIDENTIAL



CONFIDENTIAL

Figure 1.- Flight paths of maneuvers made in vertical plane. Entering velocity 223 m.p.h. (60 per cent rated power).

CONFIDENTIAL

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

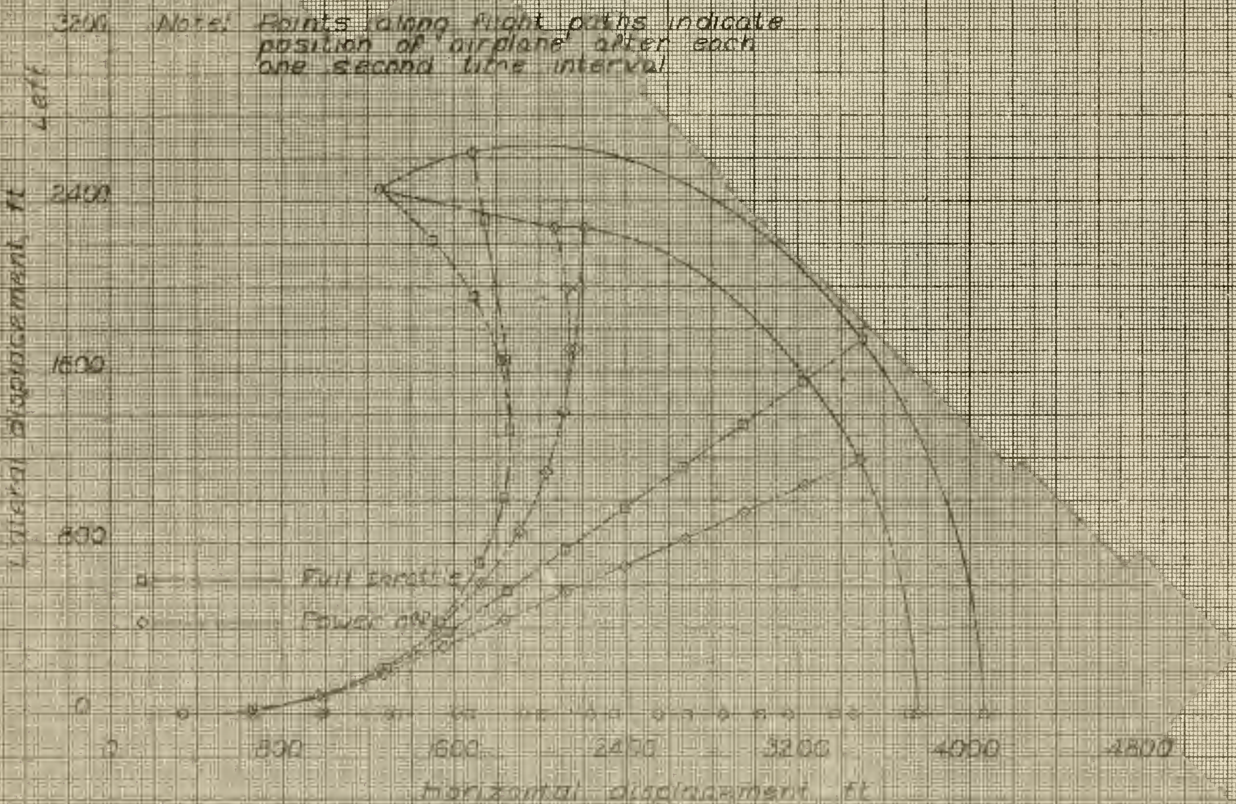


Figure 8 - Flight paths of maneuvers made in horizontal plane.
Entering velocity 233 mph (69 percent rated power).

CONFIDENTIAL

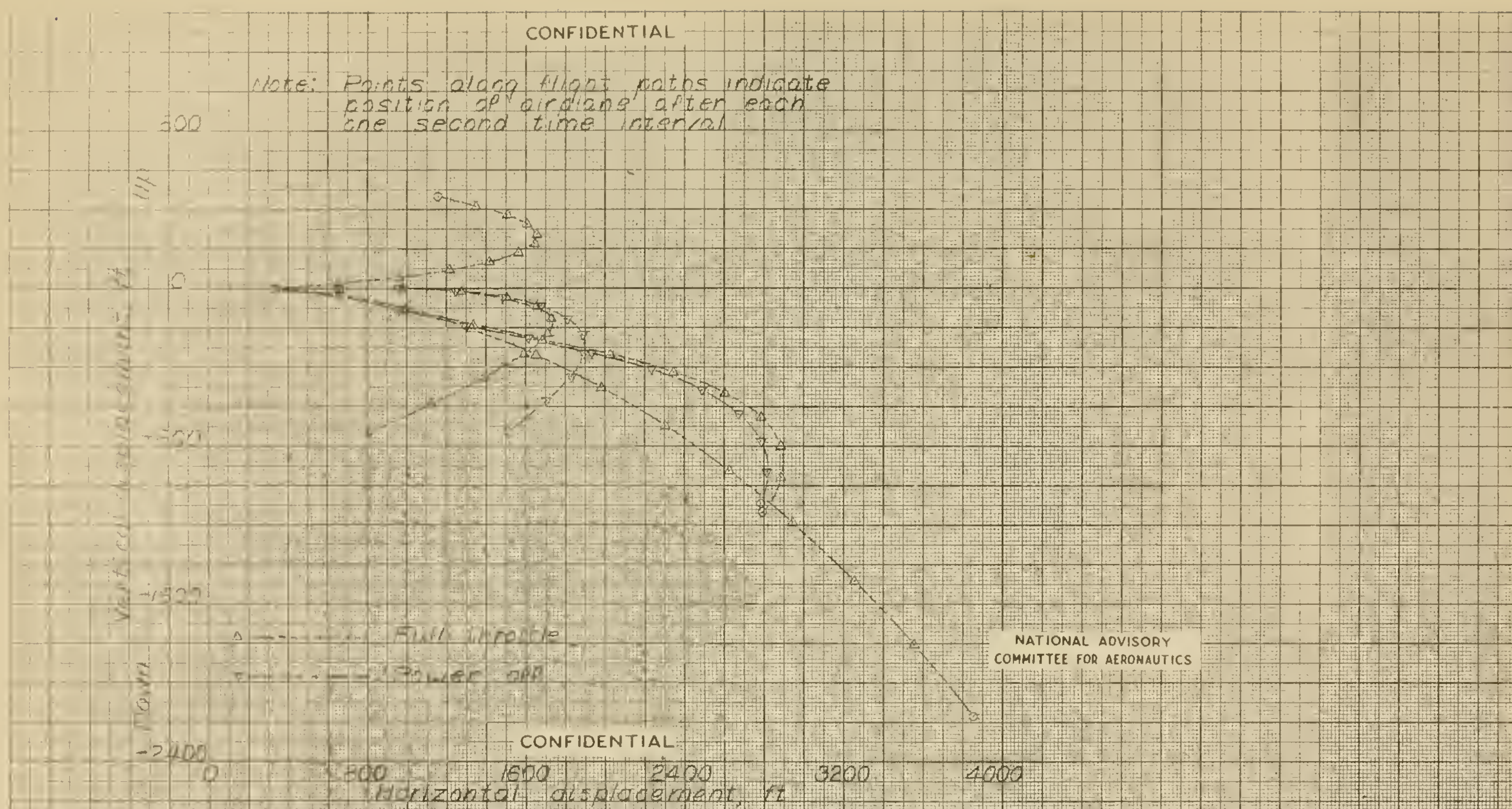


Figure 34.- Projection on vertical plane of flight paths for various turning maneuvers. Entering velocity 223 mph (60 per cent rated power).

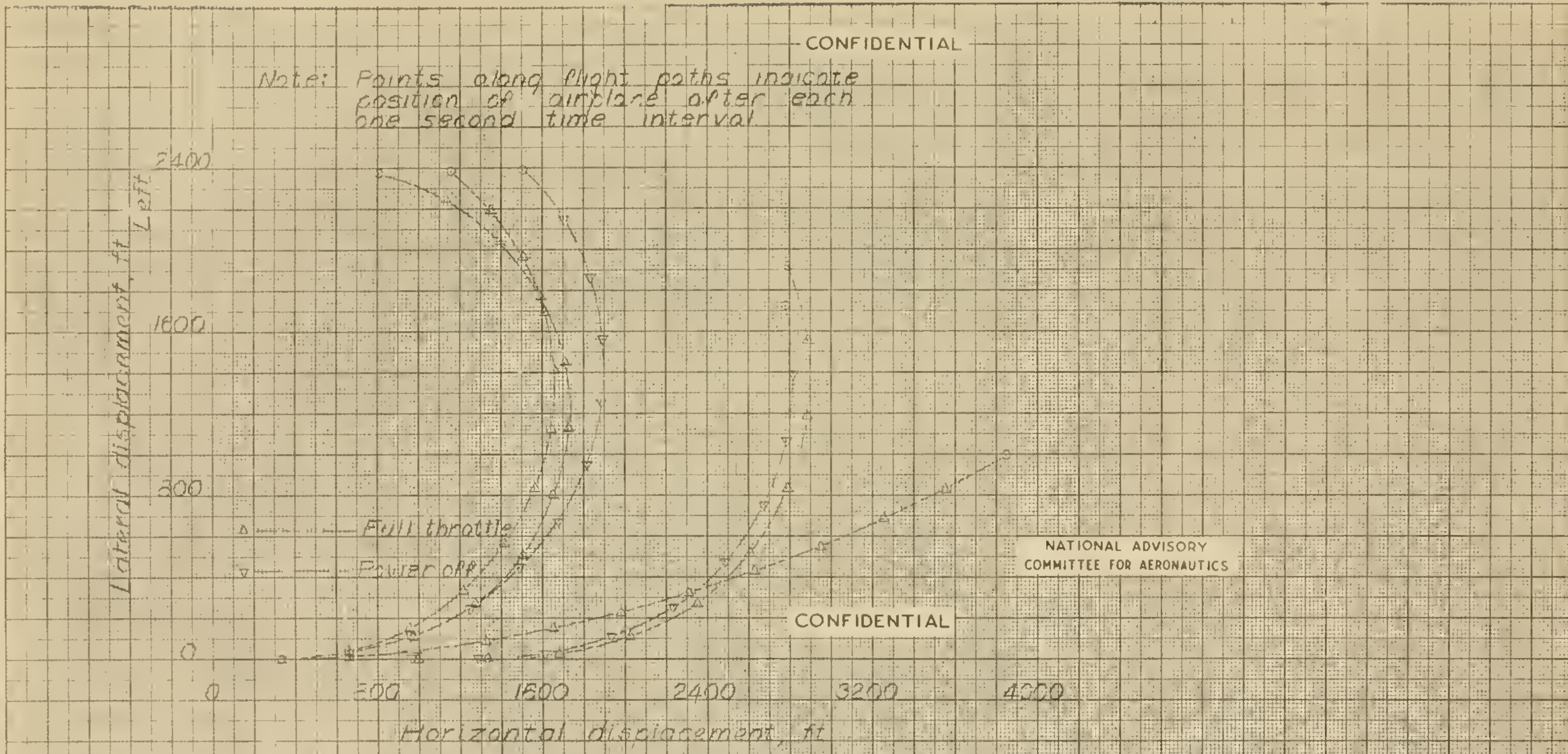


Figure 4.- Projection on horizontal plane of flight paths for various turning maneuvers. Entering velocity 223 mph (... per cent rated power).

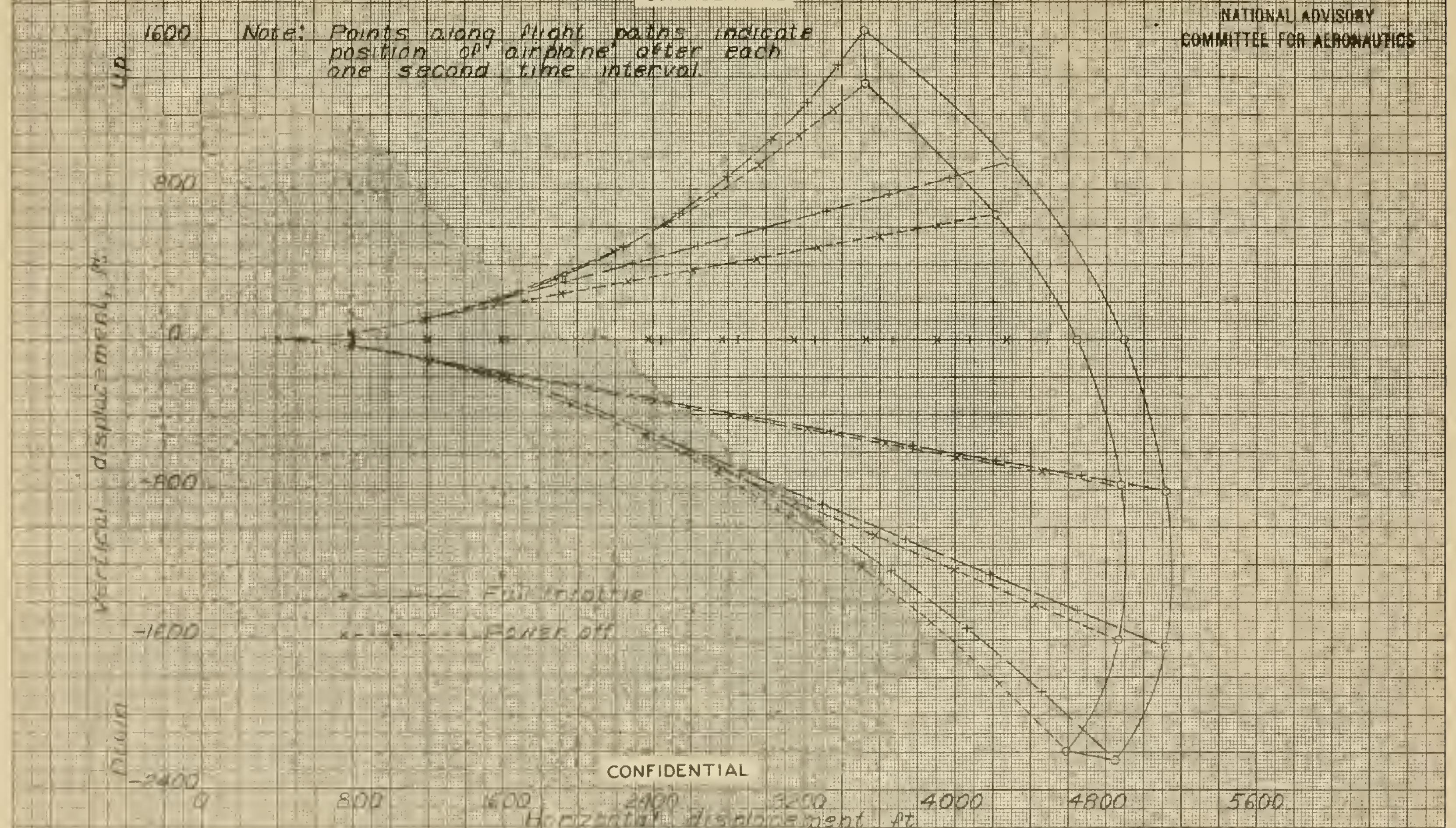
CONFIDENTIAL

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

CONFIDENTIAL

Figure 5.- Side view and horizontal sections of locus of bomber at end of 12 second time interval. Entering velocity 223 mph.

CONFIDENTIAL



CONFIDENTIAL

Figure 6.- Flight paths of maneuvers made in vertical plane. Entering velocity 276 mph (100 per cent rated power).

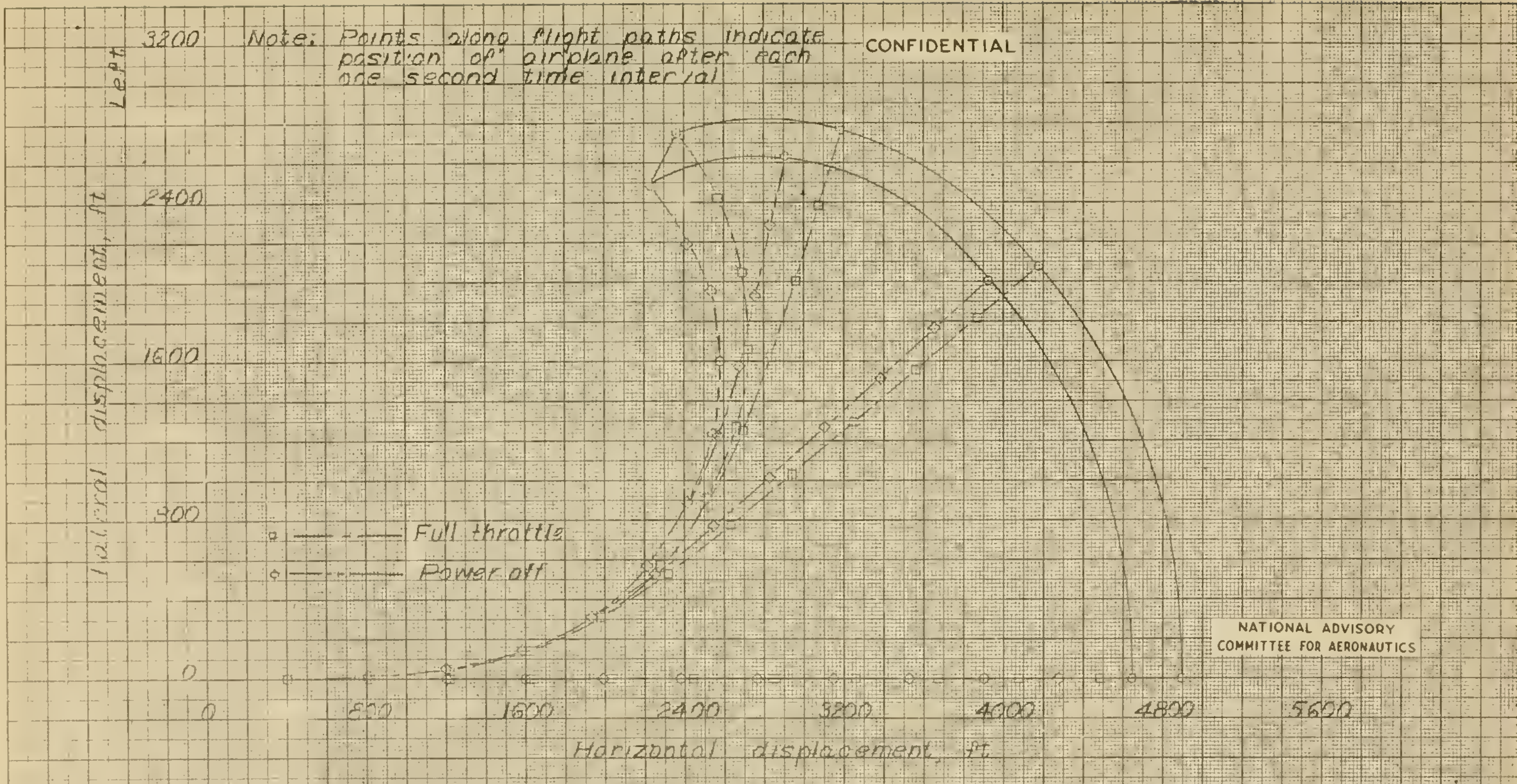
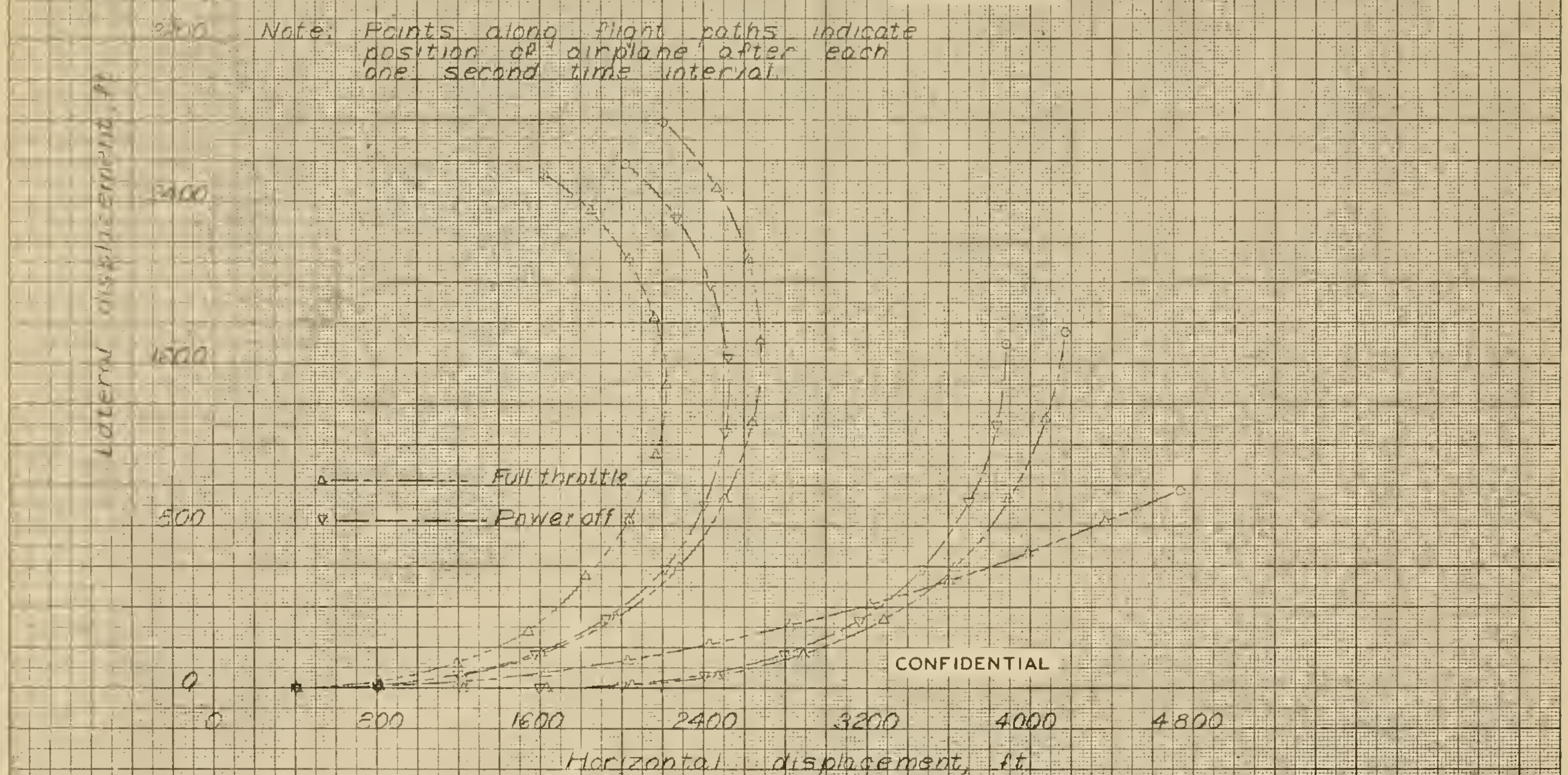


Figure 7.- Flight paths of maneuvers made in horizontal plane. Entering velocity 276 mph (100 per cent rated power).

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

CONFIDENTIAL

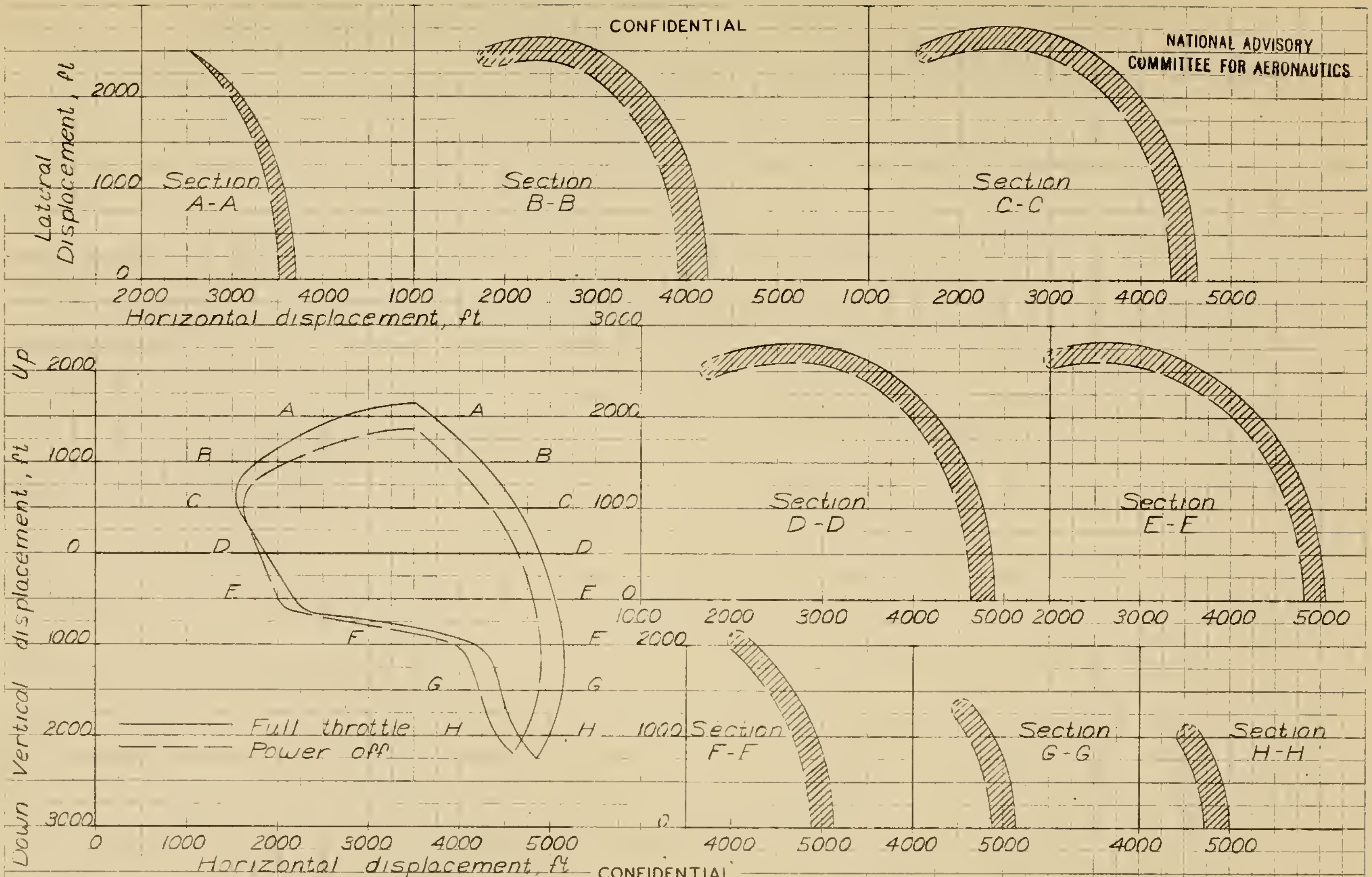


CONFIDENTIAL

Figure 9.- Projection on horizontal plane of flight paths for various turning maneuvers. Entering velocity 276 mph (100 per cent rated power).

CONFIDENTIAL

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS



CONFIDENTIAL

Figure 10- Side view and horizontal sections of locus of bomber at end of 12 second time interval. Entering velocity 276 mph.